FURTHER ELECTRON MICROSCOPE STUDIES ON ARTHROPOD TRACHEÆ[1]

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In an earlier issue of this Journal we have presented electron micrographs of tracheæ and tracheoles of the honey bee, the house mosquito and the American cockroach. Subsequently we have examined similarly prepared material from the larva of an unidentified scarabæid beetle and from adults of a millipede (*Fontaria* sp.), a centipede (*Scolopendra* sp.) and the common dog tick (*Dermacentor variabilis*). Since the pictures are similar to ones previously published, no illustrations are given in this note.

The centipede preparations showed only the expected tænidia and need not be described further.

In the tick a trachea (tracheole) approximately 0.7 μ in diameter shows supporting tænidial rings varying from 0.03 μ to 0.10 μ in width. The intertænidial membrane is not more than 0.02 μ thick and may be somewhat thinner than this.

In the millipede numerous tracheæ (tracheoles) varying from 1 μ to 3 μ in diameter were examined. All showed tænidia, ringforms being commoner than helices. The tænidia vary in width from 0.05 μ to 0.10 μ, the size being correlated with the size of the trachea. The intertænidial membrane is not more than 0.02 μ thick.

In the beetle larva approximately 25 tracheæ (tracheoles) ranging in diameter from 0.3 μ to 0.7 μ (most of these were 0.3–0.5 μ in diameter) were examined. All of these showed supporting helical tænidia approximately 0.04 μ broad. The intertænidial

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membrane is considerably thinner than the tænidia but cannot be estimated accurately from these micrographs.

It has been said that tracheæ differ from tracheoles by the presence of supporting thickenings called tænidia (see Richards and Anderson, 1942). There are several examples in which supporting tænidia have been reported absent, namely the Onychophora (*Peripatus* spp.), the smaller tubes of millipedes, and the so-called tracheoles of insects, this last being the classical example. Fresh material of Onychophora was not available for study but Dakin (1920) has already reported that with fresh material and favorable lighting tænidia can be discerned with the light microscope. Herein we report the presence of tænidia in the small tracheæ of millipedes although these are not discernible with the light microscope. We have already reported and figured (*loc. cit.*) tænidia in adult honey bee tracheoles (diameter 0.2 μ) and now report the same for tracheoles of a beetle larva (diameter 0.3–0.7 μ) and tracheoles of the mosquito pupa (diameter 0.5 μ). It seems probable, therefore, that the respiratory tubes of arthropods always possess supporting tænidia although in the case of minute tubules these thickenings are below the resolving powers of the light microscope. A distinction betwen tracheæ and tracheoles thus becomes questionable and of doubtful value.

There are two factors that would seem important in the construction of respiratory tubes, namely adequate support and adequate thinness to facilitate gaseous diffusion. It does not seem feasible to compute the amount of support given by these helical and circular thickenings but obviously tænidia do serve a supporting function. And the strength of the ribbed tube must be intermediate between that of a simple tube with the thickness of intertænidial membranes and a tube with the thickness of tænidia. In a teleological sense tracheal structure may be viewed as a compromise between the necessity of support and the desirability of a thin membrane.[4]

[4] It is commonly assumed that tracheæ are impermeable, and that the tracheoles are the loci of gaseous diffusion. This is not entirely true. Edwards (1940) has shown that tracheæ (as well as tracheoles) are permeable to fluids under certain conditions and so must be permeable to gases. We have shown that the intertænidial membrane of moderate-sized and even of some large-sized tracheæ is only 0.01–0.02 μ thick and that this is not

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greatly different from the thickness of the walls of tracheæ (tracheoles) that are only 0.2–1.0 μ in diameter. Of course, diffusion is also conditioned by the cells surrounding these tubes and by chemical differences between various tubes (if such exist), but there seems to be no reason for assuming that the tracheæ have no significant part in the diffusion of gases to their immediate surroundings.